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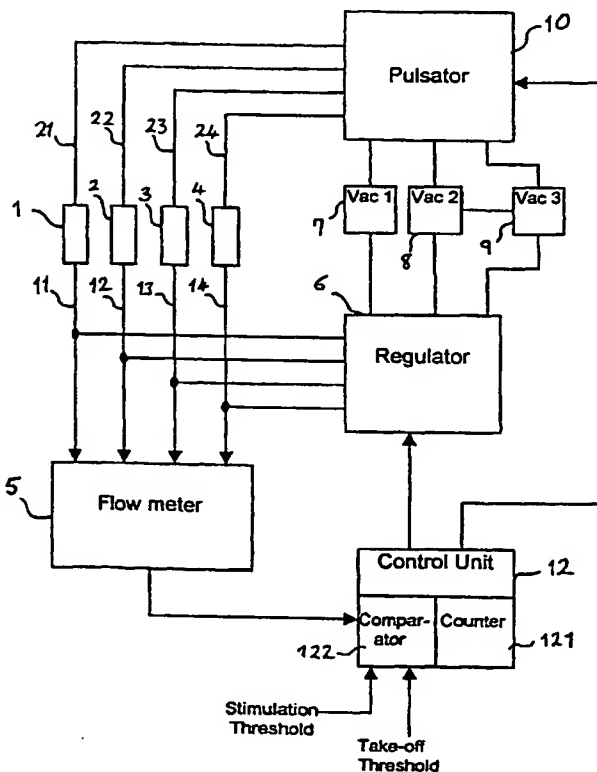
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9903286-4 15 September 1999 (15.09.1999) **SE**
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[Continued on next page]

(54) Title: AN ARRANGEMENT FOR AUTOMATICALLY MILKING ANIMALS



(57) Abstract: An arrangement for milking animals is proposed with which milking is conducted separately for each udder quarter. The arrangement includes teat cups (1-4), each with a conduit (11-14) for transporting milk away from said teat cups under application of a vacuum. A flow meter is coupled to each conduit for measuring the milk flow produced by each udder quarter and a vacuum regulator (6) is also coupled to each conduit for varying the vacuum applied to each teat cups separately. A control unit (12) is provided for controlling the application of a vacuum to any one teat cup by the regulator in response to an increase in sensed flow rate from the same teat cup, and to reduce the vacuum applied to any one teat cup in response to a decrease in sensed flow rate from that same teat cup.

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An arrangement for automatically milking animalsField of invention

5 The present invention is directed to an arrangement and a method for milking animals. The invention relates particularly to the control of the vacuum and pulsation applied to the teats of an animal so as to prevent injury to the teats and obtain a maximum milking yield.

10 Background art

It is known to vary the vacuum and pulsation rate and pulsation ratio applied to the teats of an animal as a function of the milk flow rate during milking. This principal is described in SE 326 064 and BE 99814 and is also generally known from the Duovac<sup>TM</sup> system available from Alfa Laval Agri AB.

15 During a first milking phase when milk flow is being stimulated, a low vacuum level and low pulsation rate with high massage ratio is applied to the teats through the teat cup cluster. As soon as an increased milk flow is detected upstream of the cluster, which indicates that milk ejection has occurred, the vacuum is increased to speed the collection of milk. When the

20 milk flow falls again at the end of milking, the system switches back to a lower vacuum to prevent injury to the teats and perform further stimulation which it is believed will increase future yield.

While this system is generally very satisfactory in most cases, it does not take

25 account of the variation in behaviour of the different udder quarters in terms of milk production. For example, it is well known that the rear udder quarters of a cow generally produce more milk than the front udder quarters. This is conventionally dealt with by attaching the rear teat cups before the front teat cups and commencing milking immediately on attachment. However, even

30 this measure is rarely sufficient to synchronise the milk production of all teats.

The result is either the application of a lower vacuum to udder quarters which still have a high milk flow, thus unnecessarily extending the milking process, or alternatively the application of the higher vacuum to teats that have effectively finished producing milk, i.e. over-milking, which can lead to teat damage in the form of lesions and ultimately infections, and also influence the milking yield.

There is thus a need to improve the known milking systems in order to prevent damage to the teats and over-milking of the animal, while effecting the milking in as rapid and efficient a manner as possible.

#### SUMMARY OF INVENTION

This object is achieved in an arrangement for milking animals, including teat cups for attachment to the teats of an animal, a conduit coupled to each teat cup for transporting milk away from said teat cups under application of a vacuum, means for sensing the rate of flow of milk from said teat cups and vacuum regulating means for varying the vacuum applied to the teat cups through the conduits. Moreover, the flow rate sensing means are coupled to all conduits and disposed to measure the rate of flow of milk from each teat cup individually and the regulating means are similarly coupled to each conduit and arranged to regulate the vacuum applied to each teat cup individually. The arrangement further includes control means coupled to both the sensing means and regulating means for controlling the regulating means to increase the vacuum applied to any one teat cup from a first vacuum level to at least a second vacuum level in response to an increase in sensed flow rate from said one teat cup.

By controlling the initial vacuum applied to each teat cup individually and linking this control with the rate of flow of milk produced by each teat, the arrangement prevents injury to the teats during milking, while simultaneously

ensuring that maximum milk yield is achieved. In a preferred arrangement the regulating means are further controlled to reduce the vacuum applied to each teat cup to at least a third vacuum level in response to a decrease in sensed flow rate from said teat cup. This further ensures that the milking process is optimally adapted to the individual milk production of each udder quarter and that over milking is avoided.

In a preferred embodiment of the invention the control means control the regulating means to increase the vacuum applied to all teat cups in response to an increase in sensed flow rate from one teat cup. Milk ejection, i.e. the release of milk from the alveoli into the udder cistern, teat cisterns and big milk ducts, can occur following the stimulation of one teat only. Thus once the milk ejection is determined by measuring the increased flow rate for one teat, it can be assumed that all udder quarters will start to produce milk in sufficient quantities for full milking to commence. By applying the higher vacuum to all teats when increased flow is detected only for one teat, valuable time can be saved at the beginning of the milking process, which will speed the milking as a whole.

The invention further resides in a method of operating a milking arrangement having teat cups for attachment to the teats of an animal, vacuum regulating means for varying the vacuum applied to each teat cup and milk flow monitoring means for sensing the flow of milk produced by each teat. The method includes the following steps: for each teat, attaching a teat cup to a teat of an animal and applying a first vacuum level to said teat cup, increasing the vacuum applied to said teat cup to at least a second vacuum level when said milk flow rate reaches a first threshold level.

In a preferred embodiment of the invention the method includes: for each teat, decreasing the vacuum applied to the teat cup to a third level when the milk

flow rate falls to a second threshold level and cutting off the vacuum after a predetermined time.

5 The method is speeded up considerably when the second vacuum level is applied to all teat cups when the milk flow rate from one teat reaches the first threshold level.

#### BRIEF DESCRIPTION OF THE DRAWINGS

10 Further objects and advantages of the present invention will become apparent from the following description of the preferred embodiments that are given by way of example with reference to the accompanying drawings. In the drawings:

15 Fig. 1 depicts a block diagram representing a milking arrangement according to the present invention, and

Fig. 2 shows a graphical representation of the sequence of events controlling the arrangement in response to the milk flow from each teat of a cow.

20

#### DETAILED DESCRIPTION OF THE DRAWINGS

The milking arrangement depicted schematically in block diagram form in Fig. 1 includes four teat cups 1-4 for attachment to each teat of an animal. In the present embodiment it is assumed that this animal is a cow. A conduit 11-14 is attached to each teat cup for transporting milk away from the teat cups. A flow meter 5 is coupled to each of these conduits 11-14 for sensing the rate of flow of the milk through each conduit individually. This flow meter 5 may be a series of e.g. mechanical flow meters arranged in each conduit. Alternatively the flow meter may be a single unit adapted to measure the flow in all four conduits 11-14. The meter 5 may also be disposed to measure the total

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quantity of milk passing through each conduit, from which the rate of flow may be calculated.

5 Each conduit 11-14 is furthermore subjected to a vacuum which is indicated by the connection of each conduit to a regulator 6 and through this to one of a number of vacuum sources 7, 8, 9. The regulator 6 selectively connects one of the vacuum sources 7, 8, 9 to the conduits 11-14. In the illustrated embodiment, three vacuum sources 7, 8, 9 are illustrated, however, it will be understood that more, or possibly fewer, vacuum sources may be provided  
10 depending on the desired result. Moreover, a single vacuum source, which generates different vacuum levels may be utilised in place of the separate sources depicted in the figure.

15 A second set of conduits 21-24 are provided, each being connected to one teat cup 1-4. These second conduits 21-24 are connected to a pulsator unit 10, which is also connected to the vacuum sources 7, 8, 9. The pulsator unit 10 is arranged to apply an alternating vacuum with varying pulsation rate and pulsation ratio to each teat cup individually.

20 A control unit 12 is connected to the flow meter 5, the vacuum regulator 6 and pulsator unit 10. The control unit 12 preferably includes some form of data processing circuitry, such as a microprocessor with associated memory, however, it may be implemented entirely in hardware. It includes a timing capability, preferably in the form of a counter 121, as well as a comparator  
25 function 122. This control unit 12 receives the sensed flow rates for each conduit 11-14 from the flow meter 5, and determines from these whether the applied vacuum should be increased or decreased or left unchanged on the basis of a comparison with predetermined threshold levels, which will be discussed with reference to Fig. 2 below. The control unit 12 further  
30 determines which pulsation rate and ratio should be applied to each teat cup.

The operation of the control unit 12 is illustrated in graphical form in Fig. 2. This figure shows the milk flow from each teat cup 1-4 against time. The milk flow curve for the first teat cup 1 is shown in a continuous line, while the curves for the remaining teat cups 2-4 are indicated by dashed lines. The graph also shows the application of different vacuum levels and a pulsation vacuum to each teat cup 1-4. The various timing sequences are illustrated for the first applied teat cup 1 only, however, the milk flow curves for the remaining teat cups and the vacuums applied to these teat cups are indicated in Fig. 2.

Starting on the left of Fig. 2, teat cup 1 is attached to the first teat prior to point A. A first vacuum level is then applied to the teat cup at step A. At the same time a pulsating vacuum is applied to the cavity between the liner and shell (not shown) of the teat cup to stimulate milk ejection. Preferred values for this first phase are a vacuum level of 35 kPa, a pulsation rate of 50 and a pulsation ratio of 30/70, that is 70% massage with the liner closed and 30% milking. Also from time A, a first threshold level, which will be referred to as the stimulation threshold level, is monitored by the control unit 12 i.e. compared with the sensed milk flow using the comparator 122,. The second teat cup 2 is then attached to a teat sometime between times A and B. At point B the same vacuum, that is the stimulation vacuum, is applied to this teat cup 2 also. Soon after this, the milk flow from the first teat cup reaches and passes the stimulation threshold level as indicated by the dashed line at C. The regulator 6 is then controlled by the control unit 12 to switch through a higher vacuum to the teat cups 1-4. This higher vacuum, preferably at a level of 45 kPa is selected to efficiently extract the milk from the udder quarters. At the same time, the stimulation pulsation is stopped thereby changing the pulsation to a milking pulsation which has a higher ratio of milking to massage compared to the stimulating pulsation. The third and fourth teat cups are applied in turn, but



since the stimulation threshold has been reached for at least one teat, the full vacuum is applied to each teat immediately on application of a vacuum.

5 As can be seen from Fig. 2 the stimulation threshold is continuously monitored until time D is reached. At this point, if the stimulation threshold has not been reached by the milk flow from any of the teats, the vacuum is switched to full milking vacuum for at least a predetermined time period until time point E is reached. Time D is set at a predetermined time period T1 after application of the fourth and last teat cup, illustrated by the point in time when  
10 a vacuum is applied to this teat cup 4. This is a final attempt to trigger milk ejection. This period of high vacuum, during which the vacuum level will not change is maintained for a second predetermined time period denoted by T2 which terminates at point E. At this point E, a second milk flow threshold level, hereinafter called the take-off threshold, is monitored by the control unit  
15 12. The take-off threshold is lower than the stimulation threshold. If the milk flow from any of the teats falls below this threshold, a take-off sequence will be started for that teat cup.

For the first teat cup 1 the milk flow falls below the take-off threshold at point  
20 F. This starts a counter or timer 121 in the control unit 12 which measures a predetermined time period called the strip time ST. This is provided to ensure that as much as possible of the remaining milk, the so-called strippings, which is left in the large cavities of the udder (udder cistern, teat cistern and big milk ducts), is removed. If, during this period ST, the milk flow rises above the  
25 take-off threshold, the control unit 12 will cancel the ST period timer or counter 121 and switch back to the main milking sequence. The ST period is restarted only when the milk flow again falls below the take-off threshold. After elapse of the time period ST, the vacuum applied to the teat cup through conduit 11 is reduced to a lower level, preferably between about 15 to 25 kPa  
30 at point G. This lower vacuum is selected to enable all milk in the teat cup to

be drawn into a collecting tank and also, in combination with the pulsation vacuum to provide further massage to the teat. This lower vacuum level is held through two further time periods, namely a low vacuum period LV which enables the vacuum in the conduit to fall to the desired level, and a sweep  
5 period SW, for ensuring that all remaining milk is swept into the collecting tank. On elapse of this last period SW at point H, the vacuum and pulsation is shut off, after which the teat cup 1 can be removed from the teat. The take-off sequence for the remaining four teat cups is identical as can be seen from the figure. While the pulsation is the same from point C onwards, i.e. after the  
10 milk flow rate of one teat has crossed the stimulation threshold, it will be understood that the pulsation rate and/or ratio could be changed once again during application of the low vacuum (at point G for teat cup 1) for each teat cup.

15 While in Fig. 2 only three vacuum levels have been illustrated, it will be understood that this does not exclude the use of further vacuum levels. This may be useful particularly at the beginning or end of the milking sequence to improve stimulation and reduce stress to the teats.

20 It is important to note that while the switch from a lower stimulating vacuum to a full milking vacuum at the beginning of the milking process may be performed for all udder quarters, this is not the case at the end of milking. The stimulation of milk ejection is effective for all udder quarters, however each udder quarter will generally produce different amounts of milk with  
25 corresponding differences in milking duration. Thus the take-off threshold is monitored for each udder quarter, and the subsequent teat cup removal follows after vacuum shut-off which in turn occurs after the sum of the time periods ST, LV and SW which are triggered when the milk flow falls below the take-off threshold.

## Claims:

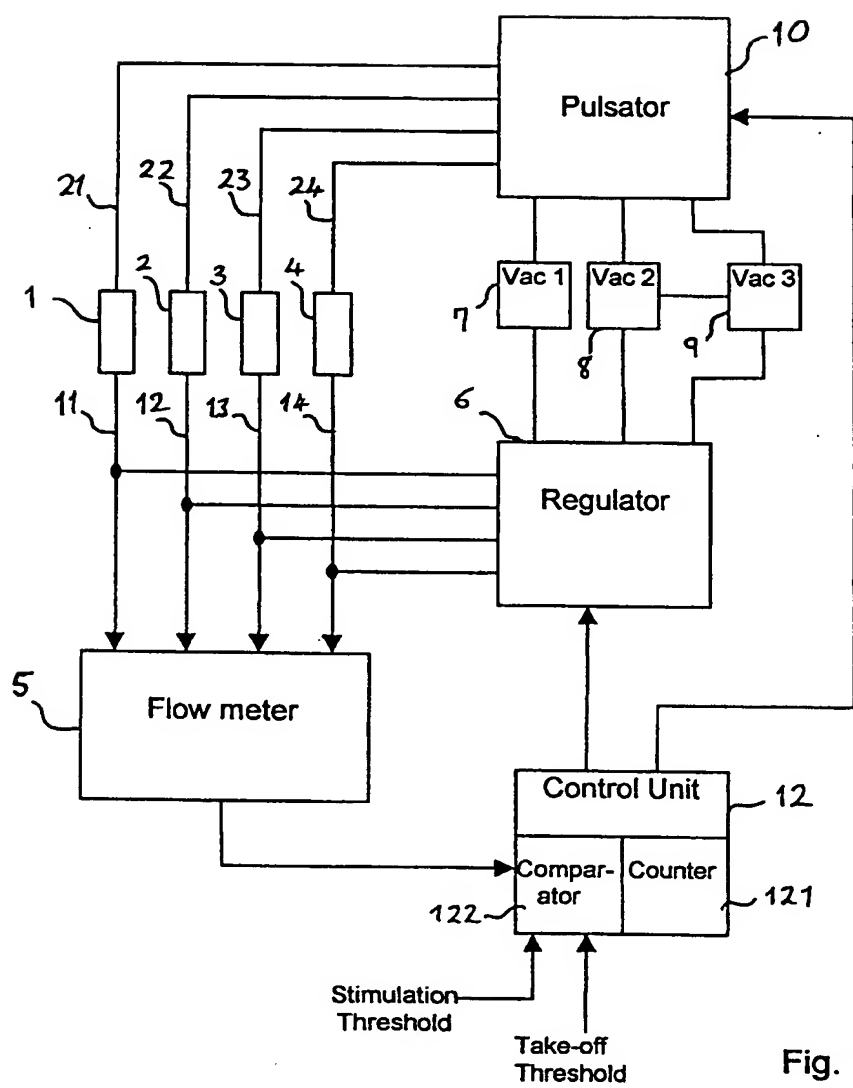
1. An arrangement for milking animals, including teat cups (1-4) for  
5 attachment to the teats of an animal, a conduit (11-14) coupled to each  
teat cup for transporting milk away from said teat cups under  
application of a vacuum, means for sensing the rate of flow of milk  
from said teat cups and vacuum regulating means (6) for varying the  
vacuum applied to said teat cups through said conduits, characterised in  
10 that said sensing means (5) are coupled to all conduits and disposed to  
measure the rate of flow of milk from each teat cup separately and that  
said regulating means (6) are coupled to each conduit and arranged to  
regulate the vacuum applied to each teat cup separately, the  
arrangement further including control means (12) coupled to both said  
15 sensing means and said regulating means for controlling the regulating  
means to increase the vacuum applied to any one teat cup from a first  
vacuum level to at least a second vacuum level in response to an  
increase in sensed flow rate from said one teat cup.
- 20 2. An arrangement as claimed in claim 1, characterised in that said control  
means (12) are further arranged to control said regulating means (6) to  
increase the vacuum applied to all teat cups (1-4) from a first vacuum  
level to a second vacuum level in response to an increase in sensed flow  
rate from one teat cup.
- 25 3. An arrangement as claimed in claim 1 or 2, characterised in that said  
control means (12) are arranged to control said regulating means (6) to  
reduce the vacuum applied to any one teat cup to a third vacuum level  
in response to a decrease in sensed flow rate from said teat cup.

4. An arrangement as claimed in any one of claims 1 to 3, further characterised by second conduits (21-24) coupled to each teat cup and pulsator means (10) coupled to each second conduit for applying an alternating vacuum at a predetermined pulsation rate to each teat cup individually, wherein said control means (12) are coupled to said pulsator means for controlling the application of a pulsation vacuum to a teat cup in response to a change in sensed flow rate from said teat cup.
5. An arrangement as claimed in any previous claim, characterised in that said control means (12) include comparator means (122) for comparing the sensed flow with at least one predetermined threshold level.
6. An arrangement as claimed in any previous claim, characterised in that said control means (12) include timer means (121) for timing at least one predetermined time period.
7. A method of operating a milking arrangement having teat cups (1-4) for attachment to the teats of an animal, vacuum regulating means (6) for varying the vacuum applied to the teat cups and milk flow monitoring means (5) for sensing the flow of milk produced by each teat, the method being characterised by the following steps:  
for each teat, attaching a teat cup to a teat of an animal and applying a first vacuum level to said teat cup,  
increasing the vacuum applied to said teat cup to a second vacuum level when said milk flow rate from said teat reaches a first threshold level.
8. A method as claimed in claim 7, further characterised by  
for each teat cup, decreasing the vacuum applied to said teat cup to a third level when said milk flow rate falls to a second threshold level,  
and

cutting off said vacuum a predetermined time period (ST, LV, SW)  
after decreasing said vacuum.

- 5
9. A method as claimed in claim 7 or 8, characterised by applying said second vacuum level to all teat cups (1-4) when the milk flow rate from one teat reaches said first threshold level.
- 10
10. A method as claimed in any one of claims 7 to 9, characterised in that said first threshold level is above said second threshold level.
11. A method as claimed in any one of claims 7 to 10, characterised in that said first vacuum level is higher than said third vacuum level.
- 15
12. A method as claimed in any one of claims 7 to 11, characterised by the steps of :  
for all teat cups (1-4), increasing said vacuum from said first vacuum level to said second vacuum level when, after a first predetermined time period (T1) after application of the last teat cup, the rate of flow from all teats is below said first threshold level.
- 20
13. A method as claimed in claim 12, characterised by commencing monitoring the milk flow from all teats to determine whether the second threshold level has been reached at the termination of a second predetermined time period (T2) following termination of said first predetermined time period (T1).
- 25
14. A method as claimed in any one of claims 7 to 13, characterised by decreasing the vacuum applied to said teat cup to a third level after elapse of a predetermined time period (ST) following the fall of said milk flow rate below said second threshold level.
- 30

15. A method as claimed in any one of claims 7 to 14, characterised by applying predetermined pulsation rates and ratios to each teat cup in association with said first, second and third vacuum levels.



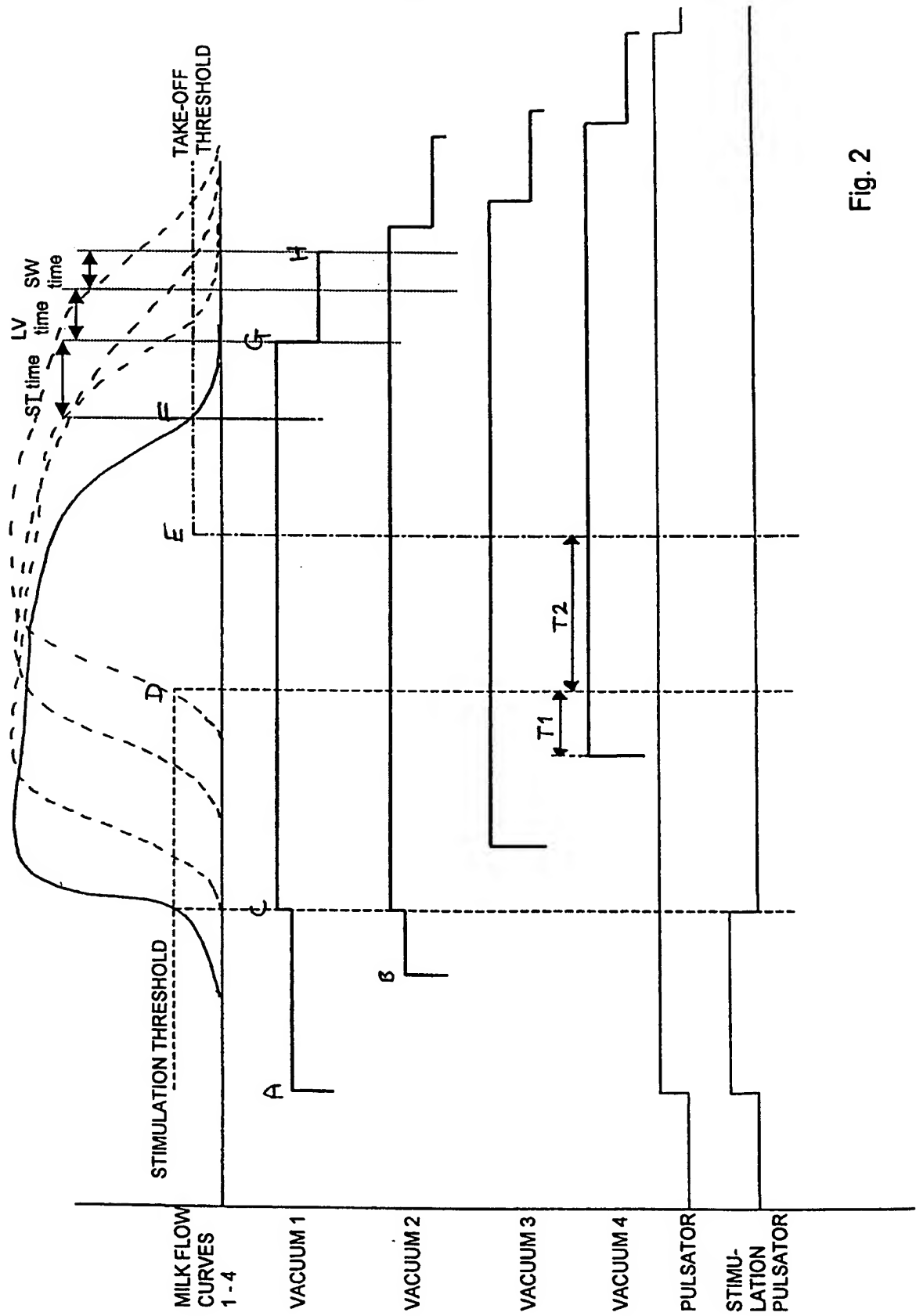


Fig. 2



# INTERNATIONAL SEARCH REPORT

Intern. Application No  
PCT/EP 00/09029

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 A01J5/007

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 A01J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the International search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 011 838 A (NORDEGREN SVEN-AKE ET AL) 15 March 1977 (1977-03-15) column 2, line 52 -column 5, line 7 claims; figures	1,3-5,7, 15
A	US 5 054 425 A (GRIMM HARTMUT ET AL) 8 October 1991 (1991-10-08) column 2, line 65 -column 3, line 38; claims	1,15
A	EP 0 679 331 A (MAASLAND NV) 2 November 1995 (1995-11-02) claims; figures	1,15
A	DE 41 13 699 A (SCHILLINGMANN DIETER DIPL ING) 29 October 1992 (1992-10-29) claims; figures	1,15

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

### \* Special categories of cited documents:

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27/12/2000

Name and mailing address of the ISA

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# INTERNATIONAL SEARCH REPORT

information on patent family members

Intern. Application No

PCT/EP 00/09029

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4011838 A	15-03-1977	CA 1051366 A DD 129034 A DE 2713269 A FR 2345072 A GB 1545676 A IT 1107732 B NZ 183672 A PL 196923 A	27-03-1979 21-12-1977 06-10-1977 21-10-1977 10-05-1979 25-11-1985 28-04-1980 02-01-1978
US 5054425 A	08-10-1991	DE 3807256 A AT 89118 T DE 68906545 D DE 68906545 T DK 211490 A EP 0423126 A WO 8907884 A	14-09-1989 15-05-1993 17-06-1993 09-09-1993 04-09-1990 24-04-1991 08-09-1989
EP 0679331 A	02-11-1995	NL 9401937 A AU 694480 B AU 1762595 A AU 5352299 A AU 713282 B AU 7417598 A US 5651329 A US 5881669 A	01-12-1995 23-07-1998 02-11-1995 09-12-1999 25-11-1999 03-09-1998 29-07-1997 16-03-1999
DE 4113699 A	29-10-1992	NONE	